DOCUMENT RESUME

ED 343 586 IR 053 868

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TITLE Cognitive Style in System Design.
PUB DATE May 91
NOTE 50p.; M.S. Thesis, Kent State University.
PUB TYPE Dissertations/Theses - Masters Theses (042)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Cognitive Processes; *Cognitive Style; *Computer System Design; *Information Retrieval; *Man Machine Systems; *Systems Analysis; Systems Development; User Needs (Information)

ABSTRACT

Different people have a diversity of needs and expectations when approaching an information retrieval system, and providing people with the ease and efficiency to access information is important when designing systems. By examining the man-machine interface from the cognitive viewpoint, it is possible to investigate how a person interacts with an information retrieval system. People with different cognitive styles prefer to interact with systems in different ways, and different styles prefer the information to be presented in different forms and formats. Systems should be designed to accommodate the diversity of cognitive styles and the different requirements of these users. Using tools like the Embedded Figures Test and/or the Myers-Briggs Indicator, an individual's cognitive style can be grouped, and the characteristics can be used to provide a more successful match between learning style and learning environment. By conceptually and descriptively evaluating cognitive styles, strategies and suggestions can be provided for more effective system design. Reasons for the inadequacies of the present systems are examined, and suggestions for the improvement of those systems are made. Some of the many possible reasons why users have difficulty inputting information into systems are also addressed. Finally, a model is provided to suggest how an information retrieval system could be constructed to accommodate the diversity of styles of users. (25 references) (Author)

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ED343586

COGNITIVE STYLE IN SYSTEM DESIGN

A Master's Research Paper submitted to the
Kent State University School of Library Science
in partial fulfillment of the requirements
for the degree Master of Library Science

by

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May, 1991

IR053868

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Abstract

Different people have a diversity of needs and expectations when approaching an information retrieval system, and providing people with the ease and efficiency to access information is important when designing systems. By examining the man-machine interface from the cognitive viewpoint, it is possible to investigate how a person interacts with an information retrieval system. People with different cognitive styles prefer to interact with systems in different ways, and different styles prefer the information to be presented in different forms and formats. Systems should be designed to accommodate the diversity of cognitive styles and the different requirements of these users. Using tools like the Embedded Figures Test and/or the Myers-Briggs Indicator, an individual's cognitive style can be grouped, and the characteristics can be used to provide a more successful match between learning style and learning environment. By conceptually and descriptively evaluating cognitive styles, strategies and suggestions can be provided for more effective system design. Reasons for the inadequacies of the present systems are examined, and suggestions for the improvements of these systems are made. Some of the many possible reasons why users have difficulty inputting information into systems are also addressed. Finally, a model is provided to suggest how an information retrieval system could be constructed to accommodate the diversity of styles of users.

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TABLE OF CONTENTS

LIST OF TABLES iv

SECTION PAGE

I. INTRODUCTION 1

II. LITERATURE REVIEW 6

III. METHODOLOGY 18

IV. FINDINGS 20

V. SUMMARY AND CONCLUSIONS 35

ENDNOTES 38

WORKS CITED 42

LIST OF TABLES

TABLE	PAGE
1.	37

I. INTRODUCTION

The world in which we live and work has become a megatrend environment, and one of the characteristics of this environment is information overload. We are in the midst of an information society where information is continuing to grow at an unprecedented rate. The oversupply of information has become an obvious problem and at the heart of the issue is the storage and retrieval of this information. When gathering information to make decisions, it has been well recognized that most decision-makers often do not need more information but rather a better ability to process the information they have. It would be useful if a user of an information system could have some influence over the amount of information he or she received, and the form in which the information was received in. Strictly speaking, different people with different information needs approach an information retrieval system with a diversity of needs and expectations. Different systems allow queries to be input differently, and the responses to the queries appear in numerous forms and formats. People do have preferences for certain systems versus others, and these preferences or the option to have choices is important in designing systems. What has to be realized is how to give people the greatest accessibility to the available information through usable technology. Given that the human-machine interface has become a part of modern life and a vital aspect of information storage and retrieval, it is important

that it should continue to be developed in such a way that is efficient, easiest, and comfortable for people to use. It is essential when designing an information retrieval system that the systems analysts take into account the human factors and information needs of the information user.

This paper will examine the man-machine interface from the cognitive viewpoint in order to study how a person's cognitive style affects the thinking process used to interact with an information retrieval system. Many of the present information and retrieval systems are restricting in the way that information may be accessed; nevertheless, it is vital that people should be able to actively participate in an information search using their own creative strategies to make decisions about the information they are receiving. Because of the individual differences among a variety of system users and the differences in the requirements and preferences that end-users bring to an information retrieval system, systems should be designed for more flexibility to accommodate the diversity of requirements and styles of end-users, where possible. Despite individuation, there appear to be various groupings of cognitive styles, and it is this diversity that systems should accommodate. It is known that different people possess different cognitive styles, and that people have individual styles in conducting online searches.[1] A person's cognitive style reflects individual differences on the thinking process, and there has been much research done on how

the presentation of information affects a person's cognitive style. This ultimately affects the way information is perceived, processed, and how effectively the interaction occurs.

Because of individual differences in processing, not everyone wants information in the same way, and people have different cognitive make-ups and use different cognitive styles or decision styles to solve problems in different situations. There are many ways to represent and test individual cognitive styles. One such measure is the Group Embedded Figures Test developed by Witkin which measures cognitive style as a function of field-dependence or field-independence.

When placed in a given environment, the field-independent style people separate a situation into different parts ignoring the parts that are unimportant to their task. Individuals possessing this style are often analytical and skilled in restructuring. The field-independent person will actively reorganize information in order to make it fit a given situation applying structure to a situation when it is needed. In learning and problem-solving, this style often adopts an approach whereby hypotheses are formed and then actively tested. A mental model of the system is usually formed, and the model is modified and improved based on experience.[2]

Field-dependent style people respond to the presented

situation as a whole without trying to analyze individual parts, reacting on the basis of what the situation does rather than what they can do with it. The field-dependent style is characterized as a holistic approach, and this style prefers and tends to rely upon the intrinsic organization of material. People possessing dominance in this style are likely to show greater interpersonal skills than the field-independent style. In assimilating information in solving problems, the field-dependent style has a tendency to assume a passive approach. People of this style like to be led in instruction and are dependent upon environmental cues.[3]

The psychologist, Carl Jung, is given credit for providing the theoretical foundations for differences in cognitive styles. Human behavior is often thought to be random and diverse, and Jung's theory of conscious psychological type is a construct that examines human behavior in a way that is quite orderly and consistent.[4] An individual's cognitive style is a type of bias that affects the way information is processed and how tasks are performed. Jung's orientation of personality includes introversion (a tendency to focus on an inner world of ideas and concepts) and extroversion (a tendency to focus on an outer world of actions and objects), and the components of this orientation are the four basic psychological functions: thinking, feeling, sensing, and intuiting.[5]

Another test of cognitive style, the Myers-Briggs Type

Indicator, adapts Jung's theories about conscious psychological type, and it is often used to indicate an individual's cognitive style in the research literature. The Myers-Briggs test is a forced choice, self-report inventory that has proven itself to be a reliable indicator of psychological type.[6]

Jung has established two bipolar functions that are representative of the manner in which an individual collects and evaluates information. The first of the bipolar functions used in collecting information is referred to by Jung as either "intuiting" or "sensing." Sensing people use a structured approach to help them make decisions. These individuals approach a problem by trying to isolate a core group of underlying principal relationships and to make a decision based on these alternatives. Intuiting people prefer to use intuition, common sense, and "gut feeling" about the future when choosing alternatives to solve problems. The intuitors like to experiment with different choices coupled with the use of feedback to make fine adjustments once a decision has been chosen. This style looks at the problem and tries to find analogies to past situational problems in an attempt to solve them in a similar fashion. The second bipolar function evaluated by Jung attempts to look at how a person evaluates information after it has been collected. This function is evaluated by the type of task and the manner in which it is performed or how the task is accessed. Jung

has tagged these different ways of appraising information as "feeling" and "thinking." In relating the use of the Myers-Briggs test to information systems, White states,

> Each of these styles has a different concept of information, and this is important in MIS design. In information gathering, the Sensor speaks of "raw data," "hard facts," and "numbers," while the Intuitor wants to look at the total problem and determine future possibilities. If one evaluates information as a Thinker, information will be entirely symbolic, preferring it presented in tabular form devoid of almost any empirical content. The information evaluation of Feelers prefers information related to humanistic issues.[7]

II. LITERATURE REVIEW

People process information differently and everyone has a special way he or she likes to see it presented, yet as noted above, people can be grouped by cognitive styles. The different cognitive make-ups people use allow them to use different cognitive styles or decision styles to interact and do problem-solving differently. These different styles are an important element in exploring the relationship existing between decision-makers and the information perceived as useful within a given decision environment. The research literature is rich with information about how a person's cognitive style affects the way information is processed and how tasks are performed.

Johnson and White explain the usefulness in analyzing cognitive styles as the differences in an individual's cognitive style affect the way he or she perceives, analyzes, and resolves problems. It has been shown that the most

effective learning occurs when an instructional program fits a student's cognitive style, and it has been suggested that given the choice, an individual will use computer models which are adaptive and allow the individual to apply his or her own style of processing information without the constraining restrictions of the system.[8] So, in order to match cognitive styles and learning situations it is necessary to find some way to recognize cognitive styles and the ability to structure the tasks or the learning environment so that they fit one another.

Henderson and Nutt measured cognitive styles using the Myers-Briggs Type Indicator in order to isolate how a person's style has an influence on decision-making behavior. They suggest that decision-makers prefer decision processes that are compatible with their decision style.[9] For example, it seems that an individual's judgmental or perceptual dimension of cognitive style is the factor that dominates the process of making a decision. The judging attitude focuses on an attitude to make quick decisions and come to conclusions, and the perception attitude holds off on making a decision until more information can be gathered. People are seen as possessing both attitudes, but being more comfortable or dominant in one of the two. The tendency toward judgmental or perceptual dominance is contingent upon an individual's tendency to be an introvert or an extrovert. The suggestion is made that it is important to study the characteristics

preferred by each cognitive style to determine which decision environments are most conducive to comfortable learning.[10]

Benbasat and Taylor studied the impact of cognitive styles on information system design, and they believe that a decision-maker learns programs, strategies, or other transformation processes which mediate behavior. Benbasat and Taylor state,

> Among the processes subsumed within cognitive styles are selective processes (filtering information), organizing processes (patterns or integrating selected information), moderating or controlling processes (e.g., motives), and adapting processes (overcoming situational constraints of the task).[11]

By reviewing the literature, Benbasat and Taylor make the following conclusions about the role of cognitive styles in information design: decision-makers differ in their data gathering styles, analytic decision-makers tend to prefer decision aids and reporting systems that are quantitative in nature, and heuristic or intuitive decision-makers need more data search capabilities and rely on feedback and trial and error (the information system should allow the possibility of providing alternate solutions).[12] The authors believe that information processing preferences need to be reflected in the designing of the information system, and that the designer of the system should be able to assure the users of the system that regardless of the user's individual cognitive style, similar levels of decision quality can be reached. Benbasat and Taylor also cite research to support the assertion that increased flexibility in the system leads to increased

confidence in decision-making.[13]

Davis, Grove, and Knowles used the Myers-Briggs Type Indicator to look at decision-making style in an interactive computer simulated business environment. The subjects were classified into four decision-making styles, they performed decision-making tasks, and their cost performance was measured. There was a significant difference between the cost performance of the four cognitive styles, especially in the perceptual dimension of the test measuring sensing and intuition. Sensing refers to an individual's awareness of sensory realities and cognitively to facts and details. Intuition is more global and focuses on insight about and within the data; intuition includes unconscicus factors. The authors concluded that the Myers-Briggs Indicator appears to be a promising measure of how cognitive styles differ in an operational decision environment.[14]

Blaylock and Rees used the Myers-Briggs Indicator to measure cognitive style and to investigate how the perceived importance of information and the perceived usableness of information varies by cognitive style. They found that information preferences varied dynamically as feedback was received, and that the value of information cannot be effectively evaluated apart from the users of that information. They conclude by stating, "there is no sense in providing information to a decision maker whose cognitive make up is such that he or she will ignore it."[15]

Borgman has reviewed literature on both online systems and bibliographic retrieval systems and focused on issues and the nature of problems that users have had with each.[16] Borgman found that more similarity exists across types of systems in conceptual problems (conceptual problems are defined as those problems that are caused by a lack of understanding of the search process) than mechanical problems.[17] Borgman found that in the studies of conceptual problems there were a significant amount of: aborted searches, attempts to input information unidentifiable by the system, and searches done with no resulting matches even though the records sought existed in the database. The dominant type of conceptual errors encountered had to do with people having difficulty in understanding how to represent their queries or needs when inputting them into the system and in terms of retrieving portions of the relevant material that exists on a given topic.[18] On the basis of her studies Borgman makes it clear that many of the design difficulties encountered by users are due to design deficiencies in the systems, but that the research on individual differences has only identified the user's range of performance and level of satisfaction and not the variables responsible for the inadequate system design.[19]

Although online public access catalogs are widely being used in libraries and have generally been well received by their users, there is considerable evidence that the user's success rates in using the catalogs leaves much to be desired.

Success rates for known items the user is searching for (e.g., call number, author, title) have been reported as 67%.[20] The success rates for subject searches have been reported as even lower. Through the analysis of user errors with online catalogs, it seems that many of the users approach the present online catalogs with unrealistic expectations and incorrect mental models of the system. The mental model is a user's model of what the system is about and how it works. The user's mental model of how to interact with the computer affects an individual's ability to problem-solve and to diagnose errors. This suggests that the end-user's performance could be improved if the user had a more accurate mental model of how the online catalog works.[21]

Cherry, Turner, and Clinton in "Online Public Access Catalogues (OPACs): Design of Instructional Software For User Training," describe a non-traditional approach taken to teach users how to use (OPACs). The authors have studied conceptually based training which teaches people how a system works rather than how to do particular tasks on a system. This approach seems to be more beneficial for complex problem-solving tasks than training based on procedural instructions.[22] The software they developed runs on Macintosh computers and uses HyperCards to incorporate text, music, graphics, digitized video images, speech, and animation.[23] Concepts are described in such a way that they apply to any online catalog. The software allows the user to use icons to

navigate through the catalog, and special features to voluntarily move around within the system (e.g., the exit button allows the user leave the system at any time, and when the button is chosen, a "dialogue box" allows users to go anywhere in the system if that is what they want to do or they can completely exit the system). No matter where the user is in the catalog they can always get elsewhere in a maximum of two moves. First they can look at a hierarchical map of where they are in the system, and then they can move the icon to where they want to go, and go there. The idea behind the conceptual software for the online catalog is that regardless of the problem solving style of an individual they will be able to just walk up to the system without knowing how to use it or without any computer experience and use it.[24]

MacGregor, Shapiro, and Niemiec studied a comparison made between cognitive style and success in a learning environment supplemented by computers and instructional software. They sought to determine if a computer augmented learning environment as opposed to traditional instruction would affect a person's achievement based on differences in cognitive style. The aspect under study was the difference between field-independence and field-dependence using the Group Embedded Figures Test.[25] The trend in the research literature shows that the field-independent person has little difficulty in the perception of discrete elements from an organized region and can react to ambiguous stimuli in an organized

manner. The field-dependent person, on the other hand, views patterns globally and focuses more on the overall organization of the encompassing field. Findings have suggested that the two different styles approach learning tasks in ways that are qualitatively different making use of different strategies; the situations in which learning occurs can have differentially influencing effects on people with dissimilar cognitive styles.[26] There can be little doubt that students are able to learn in environments where their style does not match the dominant teaching approach; however, it is beneficial to identify the learning environments that will coincide with the way a student functions in order to greater motivate by catering to an approach in accord with the way he or she processes information. The goal is to optimize learning and to increase an individual's processing productivity by matching the style with the environment. It is only after this is achieved that the structure, meaning, and rate of presentation can accommodate the needs of the user and an optimal learning environment can be created.[27]

Lambert and Newsome studied how conceptual differences in problem representation were evaluated between experts and novices. The problem representation was either abstract or concrete and was used to measure performance on an expert system used for an analysis of problem-solving. Researchers examined an employee's performance (accuracy and speed). The findings suggested that low-skill employees conceptually

organized their knowledge of the problem solution differently than the high-skill employees.[28] It seems that a necessary prerequisite for building a successful expert system is that it can be used by multiple users possessing different skills and problem-solving abilities. One system should accommodate many users, and the less-skilled or novice users should be aided by the system in terms of problem-solving support by having information presented in a form that is conducive to the novice's conceptual understanding and organization of the query or problem knowledge. Systems should present alternatives to problem solutions in a way that leads to the reductions of uncertainty associated with the probable solutions. The systems should also aid the novice user in the selection of these alternatives.[29] Confidence is a critical issue in the analysis of system usage, and the results of this study revealed that self-reported confidence is linked to the amount of time it takes an employee to perform. Regardless of the skill level of the employee, the longer it took to solve the problem using the system, the lower was the level of confidence in the recommendations.[30]

Coventry examined the field-dependent and field-independent dimensions of cognitive style to study how these differences affect the way a person organizes and processes information which has been shown to be an important factor in how an individual learns to use a computer system. Subjects were shown some commands and given specific tasks to be

performed using the UNIX operating system and to ask for assistance when it was needed. Online documentation and verbal assistance were available to the participants, and they were not discouraged from asking. The results of the study showed that the field-dependent subjects were less likely to know a command needed to complete a task, and when they did not know a command, they were more likely than the field-independent people to ask questions. The field-independent subjects, on the other hand, were more likely to try the task through trial and error than to ask for help.[31] The results have indicated that there is a need for differing forms of help systems for these two groups. In most problem-solving situations, an individual will adopt a heuristic that coincides with his or her cognitive style. However, individuals may choose heuristics that are not part of their dominant style. These differences may occur in an individual's heuristics when a task is biased towards a particular strategy and/or where an individual feels stressed or is panicked and so reverts to a less sophisticated strategy. These types of situations may occur when an individual is unfamiliar with a system or is pressured by a lack of time.[32]

Based on the observations of the help asked for by the two styles it is possible to construct a model of the varieties of help needed by the user to increase their knowledge of the commands. For field-dependent people it

would prove useful to find a way to inspire the user to find out more about the system by increasing their knowledge of the available commands. For example, an adaptable synonym feature could be adapted into a question and answer mode allowing a user to spontaneously ask questions about how to do something such as "How do I save a program?" This would also be useful for field-independent people requiring supplemental help with the formation of the syntax of commands. It has also been suggested that this user may require a preventative and protective measure which stops the user from experimenting and carrying out mistakes that cannot be undone once they have been made. It would be helpful if the user could find out beforehand what is going to happen if a command is used before it is actually employed. Finally, it is often suggested that users would like more communication resulting from the instrumentation of a command with messages such as "you have just changed your password," etc. Rather than just returning to a screen with a prompt on it, visible feedback should be an option when desired. People fall on a continuum of cognitive style differences and so they may require a balance between different types of help provided by the system. One thing is certain; the entirety of system functions are vast, and the average user only learns as little as possible to get the job done.[33]

In an attempt to fully utilize human resources in the development of system design technology, White has looked at

the characteristics of individual's cognitive styles comprising MIS project teams, and the effect this has had on project success. There has been very little research done on assembling project teams, and this research is an attempt to come up with a methodological approach. A case study of two MIS project teams was conducted in which each team developed a computerized entry order system. One team contained all four of the Jungian perceptual types (ST, NT, SF, and NF) [see table 1][34], and the other contained only two (NT and ST). Users of the product developed by the team containing all perceptual types expressed satisfaction with the system developed as well as with the process used of letting the users get involved with the design of the system. However, the group with the (SF and NF individuals) revealed a complete void in the feeling aspect, got caught up in technical detail and a communication gap was revealed between the group members and the users of the system. There was an overall dissatisfaction with the team's activities.[35] And White quotes Myers who states: "If people are exactly the same type, they will understand each other very well but will not make the strongest team because they will be prone to commit the same mistakes."[36] It has also been suggested that thinkers need feelers to forecast what others will feel and to understand the intent beyond spoken words. Based on the evidence presented in the study it has become apparent that the recognition of the perceptual component strengths of

individuals in project teams should be carefully assessed in order to increase the likelihood of the successfully undertaking a plan to construct a model, and the implementation into a design for an information retrieval system.[37]

III. METHODOLOGY

By reviewing the research literature, it has become evident that the relationship between a person's cognitive style and the computer-aided decision environment in which the person is operating is often an essential element in determining how successful the human-computer interaction will be. When this interaction is examined in the context of the cognitive viewpoint we are able to recognize that: perception, recognition and memory, information processing, and the arrangements of knowledge are occurring at both ends of a communication system.[38] In this regard, Belkin refers to Harbo, Ingwersen, and Timmermann and quotes, "the task of [sic] [information retrieval] is to bring cognitive structures of authors, system designers and indexers into accord with those of the information worker and the user, in order to cope with the actual need."[39] By analyzing cognitive styles it is possible to discover individual differences in the thinking process, but in the past, the end-user has been faced with the difficulty that many information retrieval systems have been developed by researchers who have often designed systems to

suit their own cognitive needs rather than the needs of diverse users. In order to improve systems by effectively matching cognitive styles and learning situations, we have to find some way to recognize cognitive styles and the ability to structure the tasks or the learning environment so that they fit one another.

This paper will embody research of a conceptual and descriptive nature in order to evaluate applications of cognitive style making suggestions for a new synthesis of ideas and providing strategies for more effective system design. In order to improve information and retrieval systems in relation to cognitive style and to implement tools like the Myers-Briggs Indicator into the design of the system, it is helpful to look at: the individual's mental model in relationship to the computer, some fundamental differences among individual users, and the interaction between the individual and the computer. Reasons for the inadequacies of the present systems will be examined, as well as some of the design deficiencies that have caused them to not be effective or efficient. Through this analysis I hope to make suggestions for the improvement of these systems. In addition, I will briefly discuss problems that have been associated with the inputting of information into a partially interactive system. Hopefully, in the future people will be able to bring their preferences to a computer intermediary and to actively choose how their interaction will occur. By

utilizing tools to group and classify diversities in human behavior, the implementation of cognitive styles into systems can become a reality. Finally, a sample model will be described to explain how cognitive style could be used to enhance the interaction between the user and the system.

IV. Findings

In the evolution of system design, the simplistic black box ideology (occurring when the inputs and the outputs of systems are examined without regard to the throughput) has or, by this point in time, should have been superseded by the white box ideology (investigating systems by studying the models they have fabricated for the mediums they are interacting with).[40] Belkin believes information science is centered around the elementary social problems of the "effective transfer of desired information from human generator to human user."[41] There can be little question that individual states of knowledge are difficult to represent, and that the better they can be represented the greater the chance of producing a successful interface. As Belkin sees it, the "problem lies in the various transformations between the generator's conceptual knowledge and the eventual information structure (and similarly between the user's conceptual structure and eventual anomalous structure)."[42] An information system that accommodates a user's cognitive style would help to produce a more effective interface. With the

present forms of interfaces, the user often has to operate in another's style, and this is much like communicating in a foreign language through the translation of the foreign language into one's own language before the meaning can become clear. The goal is to be able to communicate without the middle ground, without the conversion back and forth or mediation. Incorporating cognitive style dimensions like those of the Myers-Briggs Indicator into the interaction would help to alleviate this problem of providing a smoother interface.

As an individual attempts to make sense of the world through interaction, the individual uses his or her own construct to interface with incoming stimuli to try to produce meaning based on the situation the person is in. It is Wilson's belief that "a cognitive view of information-seeking behaviour and information use implies that we understand the relationship between the meanings of the everyday lives of people, and the information which may have relevance for those lives."[43] The mental models or images that people have of themselves and their environments provide a framework for meaning, and it is because of this common ground that we are able to group our relationships and differences. These meanings are socially, as well as, individually constructed and are important, because they furnish the basis for: the development of modes of behavior that is considered socially typical, a definition of meaning, and framework for deciding

what is relevant.[44] The Myers-Briggs Type Indicator is an excellent empirical tool for a classification of individual differences. The individual differences can be recorded, and input into a system in an attempt to customize the response and the output to an individual user. It is only by classification, in an attempt to understand individual knowledge structures used to understand, construct meaning, and act in particular situations, that how and why people involve themselves in information seeking behavior can be greater known, and the user's actual need can be addressed. The individual brings genetic and social factors with him or her to the information system. The Myers-Briggs Indicator is just one way to measure these factors, but it is one that has been shown to be a reliable indicator and has been vastly used in the literature. The behavior of the individual depends upon the effectiveness of the interaction. The factors influencing this interaction are as many as the people being considered, yet there needs to be a way customize interaction so that factors such as problem solving behavior, decision-making, and the use of individual mental pictures can be used to work for the individual and not against him or her. The Myers-Briggs Indicator has been shown to be a valid and reliable measure of cognitive styles, and there needs to be a way for the user to take advantage of the knowledge of his or her own style should the user choose to.

With an interactive system there is feedback at every

stage of the process, and the human element is an essential part of system design. Not only can the human user reformulate his problem when desired, but he can come to a better, often evolving, understanding of what his need really is. This is possible only because of the continual feedback from the machine that he is receiving and to which he is responding. The user of an interactive information retrieval system is able to formulate and reformulate his or her problem while in contact with the machine, but is also reappraising and understanding his need in terms of the machine's feedback to him.[45] We must not allow ourselves to adopt a position whereby communication is viewed as a process where data is inputted and outputted through a physical channel and on either end of the channel are a sender and receiver. Instead, by focusing on the presence of the human element, one of two scenarios should be present: (1) either the user should be able to input information about themselves, and the system via interface software could present information in format that is adaptive to the user's cognitive style, or (2) at the very least the user should be able to actively make a choice by being given the option of selecting one of several available formats. In order to provide an optimum interaction between the human-machine interface, an understanding of the needs and limitations of human behavior is vital for an effective and efficient interface to occur.

In trying to understand why the present forms of

interactive systems are inadequate it is necessary to examine four possible explanations as to why these systems have not evolved as the vendors have predicted.

First, there has been a lack of corresponding development on the vendors' behalf to include incremental changes in the evolutionary stages of software and hardware development. The systems have continually been developed and built without enough regard for the people who will be using the systems. More attention must be focused on the end-user's ability to interface with and adapt to certain systems in a given way, as different people will prefer different ways of interaction. People do not absorb information in the same way and individual human information processing in decision environments results in biases in the acquisition, analysis, and the interpretation of the information. More attention must be paid to the diversity of cognitive styles of similar individuals and ultimately the system users must provide initiative in changing the form of the system instead of just accepting every system placed before them. Simple supply and demand in the marketplace is not enough.[46]

When a person interacts with a computer, what is sought is a system that is oriented toward the user. Groupings of users should be able to walk up to the computer and control the interaction in order to best satisfy their information need(s). However, presently it is the computer that restricts and controls the user's behavior. Excessive control by the

computer may provide guidance and structure for a field-dependent person, but it may greatly restrict a field-independent person. A system that is inflexible, such as requiring only fixed length inputs, has been shown to increase the speed by which field-independent person performed computer presented tasks. At the other end of the spectrum, the computer may be excessively inscrutable to the user providing no external referents, such as insufficient visual feedback, and so that the user is unable to succeed. This scenario usually poses great difficulty for the field-dependent person but gives the field-independent person plenty of freedom.[47] Similarly, in Jungian terms the ST and NT styles would most likely correspond to the field-independent person using an impersonal and logical approach, while the SF and NF styles would have characteristics of the field-dependent person relying on additional referents to fully utilize the systems possibilities. A person who has never used an information retrieval system is probably not going to know whether he or she prefers to work within a structured framework or one where there is more freedom to input information in a format desired by the user. Regardless, the important thing is that the user is aware there are several choices, and that he or she can decide whether they will control the computer or be controlled by it.

In attempting to minimize anxiety, frustration, fear, errors, and an inability to proceed, it is helpful if a

learner of a computer is provided with initiative to build a mental model of the system to produce effective learning. Unguided exploration gives users the opportunity to become comfortable and familiar with a system and to learn how to move within and throughout the system using strategies that they plan and develop as they go along. The only feedback the user receives is from the computer through the interaction itself. An important development resulting from the unassisted exploration is individual differences. The observed differences include such things as: the methods people use in order to complete a task, the time it takes to accomplish this goal, and the number of parts of the system that are explored. The field-dependent persons are: less likely to explore the system, usually do not structure the information they acquire, and they like to learn each command individually, preferring to be guided through the interaction. It usually takes the field-independent persons less time to find out about the system, and they structurally organize the information they learn. Regardless of the cognitive style, both types are victims of incomplete learning and memory overload when too much information is accessed too soon.[48] Again, the grouping of field-independence and field-dependence is very similar to the dichotomy between (ST and NT) and (SF and NF). What is needed is the precise mapping of the various cognitive styles combined with software that accommodates these differences. Then it will be up to the user to choose

mode the system will be operated in.

A second reason why interactive systems have not developed as expected has to do with the problem of online systems providing generic solutions to specific inquiries. The system and all of its components should be specifically designed for a given environment, and the design of the system should be in accord with the inquiries or tasks put to the system. It is also vitally important that system design should also fit the characteristics of the individuals and of the organization using the system.[49] A system placed in the context of a college or university utilizing Library of Congress (LC) classification and to be used primarily by the student body should not realistically expect users to be familiar with the LC terms. Instead, once a term is inputted that is not a Library of Congress Subject Heading (LCSH), the system's thesaurus should map out related terms on the screen giving the user an option to substitute an alternate choice.

A third area of importance is concerned with the possibility that the users should have the option of being trained by the system so as to better perform the desired tasks, and the support of the system's user should continue and be ongoing even after the user can functionally use the system.[50] The system should provide options for training. It is not suggested that a user can become an expert online searcher after a ten or fifteen minute tutorial; however, one suggestion would be to simulate an actual search on a CD-ROM

database system showing how to combine various terms using Boolean operators and then showing how to print desired records. There could be many search simulations offered, and they could be offered in varying degrees of complexity utilizing descriptors, predefined codes, etc. This type of simulation would be in addition to the present forms of help menus and could be operated by keyboard or mouse.

Lastly, the capabilities offered by the online systems are often overwhelming to the user as too much information is offered too fast or on the opposite extreme, the expert user is often forced to tiresomely trudge through a seemingly endless menu-driven system. Either way the result is that the system cannot be utilized as it should be, and the user often becomes frustrated. In order for a system to be successful there must be a need and a desire to become familiar with the system and use it. There need to be varying levels of help so that different levels of users can forego the most basic of help menus. Also a user should be able seek help from a system while in the midst of a search and without losing or sacrificing the progress or work completed on this search.[51]

Next, some typical problems will be addressed that occur when the user attempts to interact while inputting information into a system. When a person works with an online catalog, almost all of the present forms of these systems offer terms for the user to use in order to formulate a query. The type of things that can be readily input are things that the user

already knows. Such items include: author, title, and call number. The present systems can handle these requests without too much difficulty, although some interface problems still occur. Many errors result from an inability of the user to understand an error that has been made. Also, biases in a given system can cause difficulties for a naive user, and inconsistencies between systems also add to the number of possible reasons that a user can fail to get the desired results. However, the real problems begin when users want information about a subject area that they know nothing or little about. Subject searches can often cause user frustration, resulting in an information need that goes unfulfilled. Because of the present forms of information retrieval systems, these types of searches often require the assistance of a reference librarian or of an information specialist. Basically, there are three reasons why these subject searches are so difficult for the user: trying to formulate the query in a manner so as to get what is needed often requires previous knowledge of the subject area, an effective search requires knowledge about the information retrieval system, its strengths and weaknesses, and finally, a successful search requires knowledge of a hierarchy of terms and of the classification system used to construct the subject areas. At the present time the principal agent responsible for retrieval problems is the uncertainty in the relationship between indexing and search strategies. And on the subject of

OPACS there have been many useful suggestions made that are aimed at improving retrieval by improving how well documents are indexed. Suggestions include: greater use of the Dewey Decimal System, using Hypertext to change the form from the customary linear file structure and to set up links in the records in many different directions, and an increased number of connections between the fields in separate records to allow navigation through databases and to facilitate online browsing.[52]

From the cognitive viewpoint it is the intermediary that is the focal point of interaction between the knowledge or information base and the end-user. The end-user is completely dependent upon this intermediary to get what he or she needs, because it is only through the intermediary that the user can communicate his information needs and only through this intermediary that the user can obtain a response to this need. So, there are two different ways to view the intermediary. The intermediary can be viewed as a limiting factor or it can be viewed as just one integral part of a larger system. And in order to understand one part, each separate part of the system has to be understood as well as the combined interaction of these parts. Either way the intermediary is an integral part of the system and the part with which the human user comes into direct contact.[53] It has often been stated by intermediaries that users usually do not specify what their information requirements are when they approach an information

system, and the explanation is given that the user often does not understand or have the faith to rely on the information resource or human intermediary.

Having examined the problems and limitations of present systems, the focus can be shifted to the future. In order to build a state-of-the-art intermediary information retrieval system, it must be constructed so it has a lot of information about the user, but it must refrain from making judgements about the user until the user's need and desires are clarified. The information should include: the subject area and type of problem the user is concerned with, how much the user presently knows about the problem and how much more he or she wishes to know, the goals, needs, and experience of the user, and how to best interact with the user to obtain this information. To include all of this into a system interface is asking a lot. What is first needed is to develop a functional model of a mechanism that will perform model-building functions. Also needed as part of the mechanism will be a simulation of the interacting, searching, and feedback operations of the intermediary.[54] However, a model of the user's problem is most likely a necessary prerequisite in order for other interaction and model-building to occur. Successful model-building will occur when both the user and the intermediary cooperate in an ongoing process of interaction in order to modify one another's models. Through education about the system and by actual interaction it is

possible for the user to understand and obtain a mental model of the information and retrieval system, yet how can the system develop a model of the user? A start would be to provide the computer intermediary with a model of the user's cognitive style. This could be done before the query process even begins by testing a person for cognitive style using the Myers-Briggs Indicator and then incorporating knowledge about preferences of this style into the software program functioning as the intermediary; or by query interaction, the computer could infer the cognitive style based on the user's behavior.

There should be no question as to the importance of designing performance technology distinctly for the human problem solver. As changes occur in the level of the user's expertise this change should be reflected in a balance of the abstract (SF or NF) and concrete (ST or NT) questions that comprise the man-machine interface. It may also support the best interests of the users by allowing the high-skill user the option of viewing the system's heuristics while keeping the heuristics concealed from the low-skill users. Alternatively, it has been suggested that at the present time it may not be technologically possible to design a system that will completely complement every user's cognitive style. It may be necessary for the user to have a good mental model (or working knowledge of how the system works) in order for the user's performance to improve. When there is a sizable amount

of cognitive incompatibility between the problem-solving strategy utilized by the end-user and by the system, the user's conceptual model of the system's problem-solving heuristics becomes a crucial element affecting the user's performance. Hence, systems must have features that allow the user's mental models to improve. Using graphical displays to display how the conceptual relationships are linked, as in a network, between the various types of problems should have a favorable effect on the user's completion of the task. In this type of interaction a problem can be seen in a very abstract level and then can be reduced in a hierarchical manner to display more intricate detail. It would seem that an interface combining a query interaction in combination with a pictorial display of the relationships between problem factors may prove to be a very productive way to provide supplemental information about the framework of solution plans. Also, being able to directly manipulate graphics allows the end-user to take a more visibly active role in the creation of a solution by combining discrete data and icons allowing more user-driven control. In essence, providing additional graphical representation is a way of accommodating alternative cognitive styles.[55]

In order for the most effective interface to occur in an unknown item search such as a subject query, what is essentially needed is a maximum interface between the intermediary and the individual user. In the future, a user

could carry around with him or her a card much like an automatic teller machine card and on this card could be the coded information describing the individual's cognitive style and background information. The card information could represent an open file which the holder of the card could change periodically when needed. The coded information on the card would be a profile of the user. It could include such background information as: age, level of education, competency in specific subject areas, previous experience using the library and/or computers, knowledge, beliefs, and details related to the task (depth, scope, requirements). The profile on the card must not be static but could be updatable, and once the card contained this information it could be inserted into the automatic "Master Librarian," which would provide the appropriate output for the user's profile. While interacting with the "Master Librarian," the user could interact with and simulate changes in output without having to change the profile card. Suppose the user usually uses a mouse but on a given day wants to use command language. Then, he just clicks the mouse to the appropriate icon and makes any changes in the form of the output, etc. The really great thing about a system like the one described is that two different users with the same query will not get the same results. And even after results have been received it will be possible to interact with the "Master Librarian" and to narrow, broaden, or change the query to user specifications. The user could also input

whether the information need has been answered and if not, why not. This can be recorded, the results tallied, and used to improve the "Master Librarian." The "Master Librarian" is a combination (OPAC) and expert system that provides user specific output. The records in the system could also include full-text retrieval of the needed document for browsing purposes. The user could look at the contents of the book to decide whether going to the tenth floor of the library is necessary. Additionally, the user could have access to their own circulation records if for some reason in recording keeping they needed to see what they had previously checked out. What is sought is total control by the user. The "Master Librarian" unlike the human librarian cannot be too busy to give an adequate or complete answer nor can it talk a user's ears off overloading the individual with unnecessary and nonessential information. Through interaction and by providing a previous profile of him or herself the user controls the interface, and since constant feedback is ongoing, the interaction, the format, and the output takes place as the user chooses. In this scenario it is the user that controls the interaction, and this is possible because information needs are tailored to an individual's cognitive style and profile.

V. Summary and Conclusions

It is essential when building information retrieval

systems that the end-user is able to select from a variety of different operating modes each of which is designed to match a particular type of human cognitive strategy. It has been shown that the shortest learning time is required when people are able to arrange a task as they see fit to meet their own needs and requirements. It is also known that individual working strategies can improve efficiency and are less stressing. In the near future it would be appropriate to see an interactive system that implements creative technology and uses a well structured framework to allow the user: explicit visualization, feedback on all of the user's actions (when desired), and interface facilities that are adaptable to and based on the user's understanding of the system and his or her individual style.[56] In order for this to occur, present systems and services need to be analyzed for their degree of interactive ease, and empirical research needs to be continued to analyze people's cognitive styles and heuristics used to perform problem-solving. The Myers-Briggs Indicator is just one measure of cognitive style, yet it is one that is used repeatedly in the literature and deserves attention. This paper has sought to magnify the importance and the potential usefulness of the cognitive style in the interaction between man or woman and machine, and it is hoped further research will provide system applications that facilitate easier information retrieval and the better fulfillment of information needs.

TABLE 1. Jungian Perceptual Types

	ST Sensing/ Thinking	NT Intuiting/ Thinking	SF Sensing/ Feeling	NF Intuiting/ Feeling
Focus of Attention	facts	possibilities	facts	possibilities
Tendency to Become	practical and matter-of fact	logical and ingenious	sympathetic	enthusiastic and insightful
Expression of Abilities	technical skills with facts and objects	theoretical and technical development	practical help and services to people	understanding and communicating with people
Method of Handling Things	impersonal analysis	impersonal analysis	personal warmth	personal warmth

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